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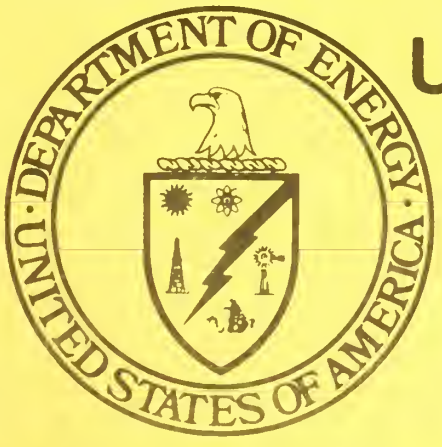
SOLAR/1090-78/10

Monthly Performance Report

ALBUQUERQUE WESTERN-II

OCTOBER 1978



U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT

ALBUQUERQUE WESTERN NO. 2

OCTOBER 1978

I. SYSTEM DESCRIPTION

Albuquerque Western No. 2 is a four-story, 110-unit apartment building in Albuquerque, New Mexico. The solar energy system consists of two independently controlled systems: one system serves domestic-hot-water (DHW) preheating needs, the other serves to preheat hot water used in space heating. Only the space heating system (System II) is described in this report.

System II has an array of tracking collectors with a gross area of 6429 square feet. The array faces south at an angle of 35 degrees to the horizontal. Water is the transfer medium that delivers solar energy from the collector array to storage. Solar energy is stored underground in a 57,000-gallon concrete storage tank. During the space heating season, the heated water from storage is continuously circulated through the building to satisfy the space heating needs for each apartment. When solar energy is insufficent to satisfy the space heating load, auxiliary heating is provided by three inline gas-fired boilers. The system, shown schematically in Figure 1, has three modes of operation.

Mode 1 - Collector-to-Storage: This mode activates when the collector-to-storage pump goes on. This occurs when adequate insolation is available, based on a minimum insolation intensity. Water is pumped through the collector and circulates back to storage.

Mode 2 - Storage-to-Space Heating: This mode activates when the storage-to-space-heating circulation pump is on. This pump runs most of the time unless storage is bypassed during maintenance or emergencies.

Mode 3 - Auxiliary Space Heating: This mode activates when the natural gas-fired boiler system (3 boilers in parallel operation) is required to "top out" the continuously circulating hot water in the space heating system in order to obtain a manually-selected temperature level. This occurs when the solar energy system can no longer meet the preset temperature.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied during the month of October, and the solar energy system was activated from the summer (inactive) mode on October 4. Water in the storage tank was heated from a low average temperature of approximately 44°F to approximately 129°F over a period of nine days before solar energy was delivered to the space heating load on October 13. Solar energy provided space heating

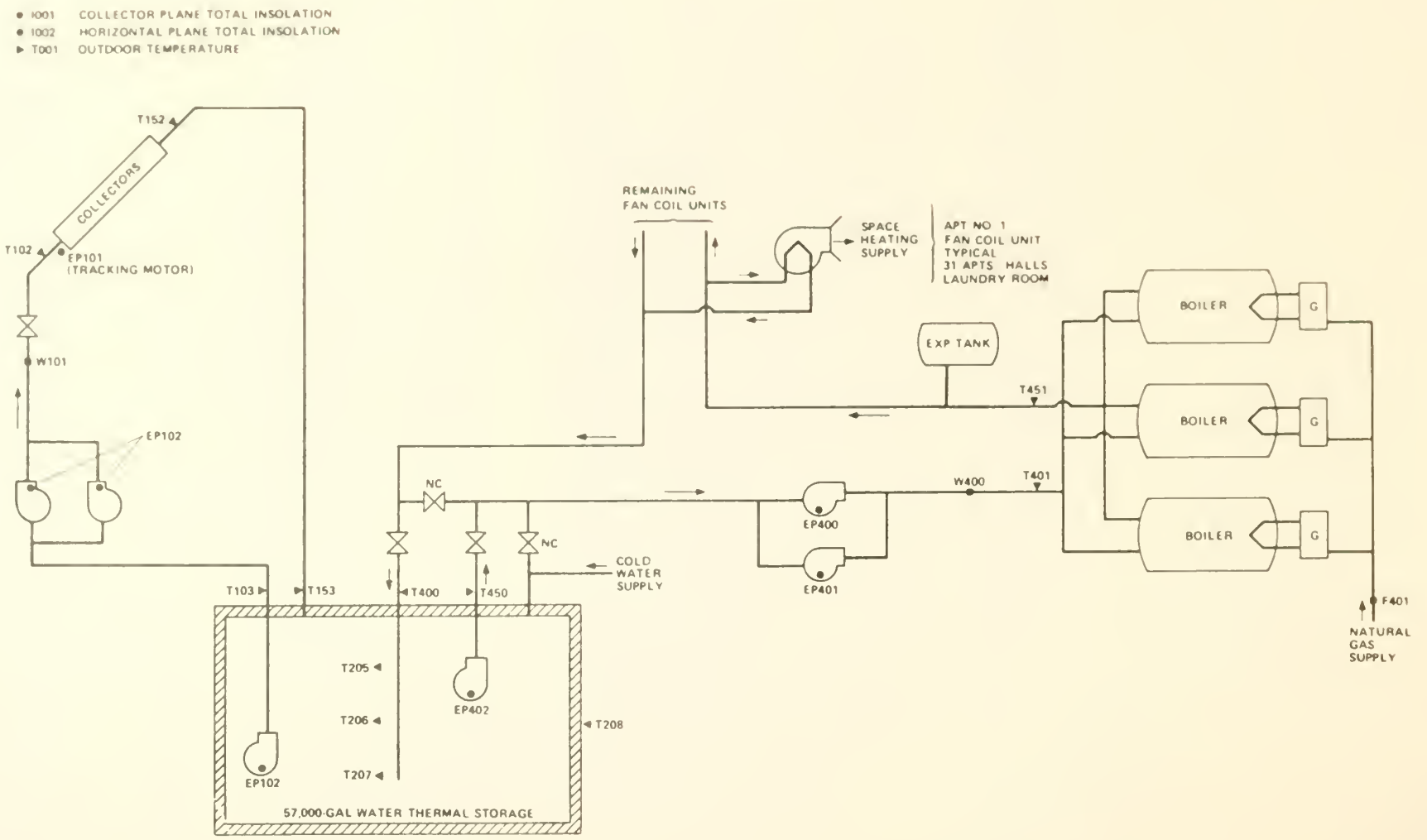

Figure 1. ALBUQUERQUE WESTERN NO. 2 SOLAR ENERGY SYSTEM SCHEMATIC

for the remainder of the month and satisfied 59 percent of the space heating load. The solar energy system provided fossil fuel energy savings of 44.1 million Btu, with an electrical energy expense of 7.7 million Btu. Because of the high flow rate in the storage to space heating loop, the temperature measurements in the loop do not provide sufficient resolution for energy balance analysis. The auxiliary energy contribution was estimated based on the fossil fuel energy consumed, the solar energy contribution was computed as the space heating load minus the auxiliary energy contribution. Storage performance was not evaluated because the amount of water actually in storage during the month was unknown.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 307.8 million Btu for a daily average of 1544 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during October of 2132 Btu per square foot for a south-facing plane with a tilt of 35 degrees to the horizontal. The average ambient temperature during October was 61°F as compared with the long-term average for October of 58°F.

THERMAL PERFORMANCE

Collector - The total incident solar radiation on the collector array for the month of October was 307.8 million Btu. During the period the collector loop was operating the total insolation amounted to 210.3 million Btu. The total collected solar energy for the month of October was 76.7 million Btu, resulting in a collector array efficiency of 25 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 76.7 million Btu. Operating energy required by the collector loop was 4.7 million Btu.

Storage - Solar energy delivered to storage was 76.7 million Btu, and there were 26.5 million Btu delivered from storage to the space heating system. The average storage temperature for the month was 104°F.

Space Heating Load - The space heating system consumed 26.5 million Btu of solar energy and 18.5 million Btu of auxiliary thermal energy (equivalent to 20.8 million Btu of auxiliary fossil fuel energy) to satisfy a space heating load of 45.1 million Btu. The solar fraction of this load was 59 percent. The space heating system consumed a total of 13.2 million Btu of operating energy, resulting in an electrical energy expense of 7.7 million Btu.

OBSERVATIONS

The collected solar energy was set equal to the energy delivered to storage, because of sensor resolution problems in the collector to storage loop. However, the error introducted by this assumption is believed small (less than 10 percent) due to very high flow rate in the loop. The problem is under investigation by IBM/Boeing.

Because of the unknown quantity of water actually in the storage tank, storage performance was not evaluated.

The missing data on October 30 and 31 were due to the temporary malfunction of data transmission.

ENERGY SAVINGS

The solar energy system provided a total fossil fuel energy savings of 44.1 million Btu while the space heating system incurred an electrical energy expense of 7.7 million Btu.

III. ACTION STATUS

IBM and Boeing are investigating the temperature resolution problem.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/10
REPORT PERIOD: OCTOBER,1978

SITE/SYSTEM DESCRIPTION:
THE SOLAR SYSTEM FOR THE ALBUQUERQUE WESTERN SITE PROVIDES FOR DOMESTIC HOT WATER (DHW) PREHEATING AND FOR SOLAR ASSISTED HOT WATER SPACE HEATING. THE SITE IS A 4 STORY, 110 UNIT HOUSING COMPLEX FOR THE ELDERLY AND HANDICAPPED. THE SITE'S SOLAR SYSTEM IS IN ACTUALITY, TWO SEPARATE SOLAR SYSTEMS; EACH SYSTEM HAVING ITS OWN COLLECTORS, STORAGE, OPERATING MODES AND CIRCULATION LOOPS. THE SYSTEMS OPERATE INDEPENDENTLY; ONE FOR DHW AND THE OTHER FOR SPACE HEATING NEEDS.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	307.816	MILLION BTU
	47879	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	76.685	MILLION BTU
	11928	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	61	DEGREES F
AVERAGE BUILDING TEMPERATURE	N.A.	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.09	
ECSS OPERATING ENERGY	4.672	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	17.822	MILLION BTU
TOTAL ENERGY CONSUMED	115.311	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	45.072	N.A.	45.072 MILLION BTU
SOLAR FRACTION	N.A.	59	N.A.	59 PERCENT
SOLAR ENERGY USED	N.A.	26.458	N.A.	26.458 MILLION BTU
OPERATING ENERGY	N.A.	13.150	N.A.	17.822 MILLION BTU
AUX. THERMAL ENERGY	N.A.	18.531	N.A.	18.531 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
AUX. FOSSIL FUEL	N.A.	20.806	N.A.	20.806 MILLION BTU
ELECTRICAL SAVINGS	N.A.	-7.678	N.A.	-7.678 MILLION BTU
FOSSIL SAVINGS	N.A.	44.096	N.A.	44.096 MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.562

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978. SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/10
REPORT PERIOD: OCTOBER,1978

SITE/SYSTEM DESCRIPTION:
THE SOLAR SYSTEM FOR THE ALBUQUERQUE WESTERN SITE PROVIDES FOR DOMESTIC HOT WATER (DHW) PREHEATING AND FOR SOLAR ASSISTED HOT WATER SPACE HEATING. THE SITE IS A 4 STORY, 110 UNIT HOUSING COMPLEX FOR THE ELDERLY AND HANDICAPPED. THE SITE'S SOLAR SYSTEM IS IN ACTUALITY, TWO SEPARATE SOLAR SYSTEMS; EACH SYSTEM HAVING ITS OWN COLLECTORS, STORAGE, OPERATING MODES AND CIRCULATION LOOPS. THE SYSTEMS OPERATE INDEPENDENTLY; ONE FOR DHW AND THE OTHER FOR SPACE HEATING NEEDS.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	324.746 GIGA JOULES
	543718 KJ/SQ.M.
COLLECTED SOLAR ENERGY	80.903 GIGA JOULES
	135455 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	16 DEGREES C
AVERAGE BUILDING TEMPERATURE	N.A. DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.09
ECSS OPERATING ENERGY	4.929 GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	18.803 GIGA JOULES
TOTAL ENERGY CONSUMED	121.653 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	47.551	N.A.	47.551 GIGA JOULES
SOLAR FRACTION	N.A.	59	N.A.	59 PERCENT
SOLAR ENERGY USED	N.A.	27.913	N.A.	27.913 GIGA JOULES
OPERATING ENERGY	N.A.	13.873	N.A.	18.803 GIGA JOULES
AUX. THERMAL ENG	N.A.	19.551	N.A.	19.551 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. FOSSIL FUEL	N.A.	21.950	N.A.	21.950 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	-8.100	N.A.	-8.100 GIGA JOULES
FOSSIL SAVINGS	N.A.	46.522	N.A.	46.522 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.562

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/10
REPORT PERIOD: OCTOBER,1978

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	11.435	73	0.000	N	0.001	N	0.000
2	11.799	72	0.000	O	0.001	O	0.000
3	11.874	67	-1.480	T	0.003	T	-0.125
4	11.946	68	-0.865		0.089		-0.072
5	12.025	65	0.018	A	0.222	A	0.001
6	10.631	64	0.000	P	0.200	P	0.000
7	11.585	68	0.000	P	0.219	P	0.000
8	11.636	67	0.000	L	0.220	L	0.000
9	9.927	67	0.000	I	0.205	I	0.000
10	11.428	68	0.000	C	0.164	C	0.000
11	11.706	66	0.000	A	0.184	A	0.000
12	12.436	57	0.000	B	0.228	B	0.000
13	11.702	56	1.432	L	0.212	L	0.122
14	11.564	57	1.879	E	0.216	E	0.163
15	11.500	64	1.783		0.217		0.155
16	11.228	65	1.626		0.217		0.145
17	10.932	67	0.923		0.172		0.084
18	10.300	65	0.857		0.189		0.083
19	9.916	60	1.051		0.169		0.106
20	9.417	64	1.386		0.187		0.147
21	1.030	56	0.759		0.008		0.737
22	7.106	56	1.115		0.089		0.157
23	1.763	48	2.792		0.007		1.584
24	4.120	48	2.083		0.042		0.506
25	4.997	50	1.497		0.077		0.299
26	10.772	47	1.887		0.203		0.175
27	11.128	50	2.184		0.210		0.196
28	11.000	53	1.846		0.210		0.168
29	11.053	56	1.977		0.209		0.179
30	*	*	*		*		*
31	*	*	*		*		*
SUM	307.816	-	26.458	N.A.	4.672	N.A.	-
AVG	9.930	61	0.853	N.A.	0.151	N.A.	0.086
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/10
REPORT PERIOD: OCTOBER,1978

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	11.435	0.000	0.000	83	0.000
2	11.799	0.000	0.000	82	0.000
3	11.874	0.000	0.000	73	0.000
4	11.946	3.296	1.568	79	0.131
5	12.025	10.471	4.993	73	0.415
6	10.631	9.099	4.081	*	0.384
7	11.585	10.188	4.368	77	0.377
8	11.636	10.184	4.323	76	0.372
9	9.927	8.656	2.984	80	0.301
10	11.428	7.596	2.752	79	0.241
11	11.706	8.382	3.269	77	0.279
12	12.436	10.878	4.369	76	0.351
13	11.702	10.099	3.421	59	0.292
14	11.564	10.097	4.023	67	0.348
15	11.500	10.040	3.963	72	0.345
16	11.228	9.841	3.782	75	0.337
17	10.932	7.746	2.093	76	0.191
18	10.300	8.551	2.384	74	0.231
19	9.916	7.037	2.624	*	0.265
20	9.417	7.981	1.759	73	0.187
21	1.030	0.011	-0.021	57	-0.020
22	7.106	3.755	1.028	65	0.145
23	1.763	0.000	0.000	48	0.000
24	4.120	1.418	0.191	52	0.046
25	4.997	3.594	0.813	58	0.163
26	10.772	9.190	3.048	53	0.283
27	11.128	9.602	3.312	58	0.298
28	11.000	9.463	3.369	63	0.306
29	11.053	9.589	3.242	64	0.293
30	*	*	*	*	*
31	*	*	*	*	*
SUM	307.816	210.322	76.685	-	-
AVG	9.930	6.785	2.474	69	0.249
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
Ø DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM SOLAR/1090-78/10
REPORT PERIOD: OCTOBER,1978

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.000	0.000	0.313	43	1.000
2	0.000	0.000	-0.126	44	1.000
3	0.000	-1.480	1.191	44	1.000
4	1.568	-0.865	3.629	50	1.763
5	4.993	0.018	6.839	61	1.373
6	4.081	0.000	5.791	74	1.419
7	4.368	0.000	5.123	86	1.173
8	4.323	0.000	4.738	97	1.096
9	2.984	0.000	2.627	105	0.880
10	2.752	0.000	1.976	110	0.718
11	3.269	0.000	3.113	115	0.952
12	4.369	0.000	3.876	123	0.887
13	3.421	1.432	0.582	129	0.589
14	4.023	1.879	0.215	128	0.521
15	3.963	1.783	0.767	130	0.644
16	3.782	1.626	0.951	132	0.681
17	2.093	0.923	-0.307	132	0.295
18	2.384	0.857	0.184	133	0.437
19	2.624	1.051	1.043	133	0.798
20	1.759	1.386	-0.889	134	0.283
21	-0.021	0.759	-3.194	129	116.938
22	1.028	1.115	-1.876	124	-0.740
23	0.000	2.792	-4.500	117	1.000
24	0.191	2.083	-2.562	109	-2.510
25	0.813	1.497	-0.989	105	0.624
26	3.048	1.887	1.669	106	1.167
27	3.312	2.184	1.328	109	1.061
28	3.369	1.846	1.388	112	0.960
29	3.242	1.977	1.018	115	0.924
30	*	*	*	*	*
31	*	*	*	*	*
SUM	76.685	26.458	36.260	-	-
AVG	2.474	0.853	1.170	104	0.818
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM
REPORT PERIOD: OCTOBER,1978

SOLAR/1090-78/10

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.000	0	0.000	0.000	0.000	N	0.001	-0.001	0.000	N	73
2	0.000	0	0.000	0.000	0.000	O	0.000	-0.001	0.000	O	72
3	-1.480	100	-1.480	0.209	0.000	T	0.000	-0.071	-2.466	T	67
4	-0.713	121	-0.865	0.382	0.152		0.000	-0.143	-1.442		68
5	0.944	2	0.018	0.327	0.926	A	1.051	-0.224	0.029	A	65
6	2.118	0	0.000	0.334	2.118	P	2.172	-0.200	0.000	P	64
7	1.805	0	0.000	0.334	1.805	P	1.712	-0.219	0.000	P	68
8	1.837	0	0.000	0.333	1.837	L	1.669	-0.220	0.000	L	67
9	1.900	0	0.000	0.334	1.900	I	1.837	-0.205	0.000	I	67
10	1.429	0	0.000	0.334	1.429	C	1.346	-0.164	0.000	C	68
11	0.966	0	0.000	0.334	0.966	A	0.748	-0.184	0.000	A	66
12	0.838	0	0.000	0.334	0.838	B	0.744	-0.228	0.000	B	67
13	2.414	59	1.432	0.404	0.983	L	0.884	-0.279	2.386	L	56
14	1.938	97	1.879	0.505	0.058	E	0.097	-0.380	3.132	E	57
15	1.842	97	1.783	0.504	0.059		0.099	-0.380	2.972		64
16	1.683	97	1.626	0.504	0.058		0.096	-0.381	2.710		65
17	0.975	95	0.923	0.504	0.051		0.086	-0.336	1.539		67
18	0.878	98	0.857	0.504	0.021		0.035	-0.353	1.429		65
19	1.108	95	1.051	0.504	0.057		0.096	-0.333	1.752		60
20	1.443	96	1.386	0.504	0.056		0.094	-0.351	2.311		64
21	0.817	93	0.759	0.504	0.058		0.096	-0.172	1.266		56
22	1.172	95	1.115	0.505	0.057		0.095	-0.253	1.858		56
23	2.926	95	2.792	0.538	0.057		0.095	-0.171	4.653		48
24	3.029	69	2.083	0.592	0.946		1.577	-0.206	3.471		48
25	2.352	64	1.497	0.591	0.856		1.426	-0.240	2.494		50
26	2.820	67	1.887	0.592	0.933		1.565	-0.367	3.146		47
27	2.687	81	2.184	0.594	0.503		0.839	-0.374	3.640		50
28	2.262	82	1.846	0.599	0.416		0.693	-0.374	3.077		53
29	2.171	91	1.977	0.599	0.194		0.323	-0.373	3.295		56
30	*	*	*	*	*		*	*	*		*
31	*	*	*	*	*		*	*	*		*
SUM	45.072	-	26.458	13.150	18.531	N.A.	20.806	-7.678	44.096	-	-
AVG	1.454	59	0.853	0.424	0.598	N.A.	0.671	-0.248	1.422	N.A.	61
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N405	N113

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: ALBUQUERQUE WESTERN - II ALBUQUERQUE,NM
REPORT PERIOD: OCTOBER,1978

SOLAR/1090-78/10

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	1779	N	73	83	N	N	N
2	1835	O	72	82	O	O	O
3	1847	T	67	73	T	T	T
4	1858		68	79			
5	1870	A	65	73	A	A	A
6	1554	P	64	*	P	P	P
7	1802	P	68	77	P	P	P
8	1810	L	67	76	L	L	L
9	1544	I	67	80	I	I	I
10	1778	C	68	79	C	C	C
11	1821	A	66	77	A	A	A
12	1934	B	67	76	B	B	B
13	1820	L	56	59	L	L	L
14	1799	E	57	67	E	E	E
15	1789		64	72			
16	1746		65	75			
17	1700		67	76			
18	1602		65	74			
19	1542		60	*			
20	1455		64	73			
21	160		56	57			
22	1105		56	65			
23	274		48	48			
24	641		48	52			
25	777		50	58			
26	1676		47	53			
27	1731		50	58			
28	1711		53	63			
29	1719		56	64			
30	*		*	*			
31	*		*	*			
SUM	47379	N.A.	-	-	-	-	-
AVG	1544	N.A.	61	69	N.A.	N.A.	N.A.
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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